## REMARKS/ARGUMENTS

The Office Action of January 2, 2008, stated that, *inter alia*, Claim 69 is rejected under 35 U.S.C. 112 as being indefinite, claims13-18, 25, 26, 32, 33, and 69 are rejected under 35 U.S.C. 103(a) as being unpatentable over Rajavel, Han, Chen and Mitra taken together, and Claims 13, 14, 16, 18 and 25 are rejected under 35 U.S.C. 102(b) as anticipated by Chen, or in the alternative under 35 U.S.C. 103(a) as obvious over Chen, Claims 13-18, 25, 26, 32, 33 and 69 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chen in view of Rajavel and Han. Applicants respectfully traverse each rejection of the claims.

Claims 13- 15, 17, 18, 25, 26, and 69 remain in this application. Claim 70 is newly added. Claims 1-12, 16, 19-24, 27-68 have been canceled.

In the Office Action dated January 2, 2008, the Examiner rejected claim 69 under 35 U.S.C. 112 second paragraph as being indefinite for failing to particularly point out the claimed invention inasmuch as the period was missing before the 97, 03, and 01. However, these periods appear on Applicant's copy of claim 69, and it is believed that the lack of periods on the Examiner's copy may be due to reproduction problems. Applicant is resubmitting claim 69 with the periods in question and will gladly provide a paper copy upon request.

In the Office Action dated January 2, 2008, the Examiner rejected claims 13-18, 25, 26, 32, 33, 69 under 35 U.S.C. 103(a) as being unpatentable over Rajavel, Han, Chen, and Mitra taken together. It is respectfully submitted that the claimed combination is patentable over the Rajavel, Han, Chen, and Mitra references. The Examiner has also used Chen as an anticipatory reference alone and in combination with Rajavel and Han at pages 5-7 of the Office Action.

The Examiner states that

> Re claims 13, 25, 32, 69, Rajavel 5,742,089 teaches multilayer structure comprising a silicon based substrate 14, epitaxial layer 18 including II-VI semiconductor material including combination of two binary alloys such as CdSe/ZnTe but lacks the specific recitation regarding all the various possible compositions as in claim 13, e.g., of $Cd_{1-z}Zn_zSe_xTe_{1-x}$ or ternay alloys $CdSe_xTe_{1-x}$. The provision of overlayer 26, e.g., HgCdTe is also taught. See column 3 line 45 to column 8 line 65.
>
> Han 7,056471 61 teaches homogeneous II-VI quarternary alloys $M_{1-x}M_{2x}A_yB_{1-y}$ having improved characteristics and easy to produce, including the specific recitation of $Zn_{1-x}Cd_xSe_yTe_{1-y}$. . . . The ternary alloy such as $Zn_xCd_{1-x}Se$, $Zn_xCd_{1-x}$, etc. is also taught. The selection of the indices to be between zero and 1 is also taught. See the abstract, column 1 line 5 et seq., column 3 line 60 et seq., column 4 line 4 to column 9 line 65.
>
> Chen . . . teaches the epitaxial material such [as] $CdSe_xTe_{1-x}$ on Si(211) substrate wherein the $CdSe_xTe_{1-x}$ wherein its characteristics of lattice

match to a[n] overlayer of HgCdTe is also taught. See the abstract page 270, 271.

It would have been obvious to one skilled in the art in practicing the above invention in Rajavel to have selected the desired quarternary compounds as claimed since such quarternary compounds are conventional, advantageous, and easy to produce as evidenced by Han. The quarternary or ternary materials correspond to proper selection of indicies in Rajavel as suggested by Han and Chen above. It would have been obvious and would have been within the purview of one skilled in the art to have selected the appropriate indicies x and z given the teachings of Han evidencing the overlapping range. Additionally such variation would have been further obvious and advantageous as evidenced by Mitra, 6,208,005, column 5 line 60-65 wherein the variation of the alloy composition would have been conventional and obvious to obtain the desired film characteristics, e.g., desired bandgap. Conversely, although Chen as applied does not recite the inclusion of Zn, such would have been obvious as shown in Han to obtain the quarternay compounds in question. The selection of suitable indicies would have been obvious as delineated above or infra.

Applicant respectfully traverses this rejection for the following reasons. Inasmuch as the Examiner has listed four references in combination, a discussion of the individual references follows.

***Rajavel*** 5,742,089 discloses a vapor phase growth infrared detector structure. In Rajavel, epitaxial silicon is grown using vapor-phase epitaxy (VPE), a modification of chemical vapor deposition. In contrast, the molecular-beam epitaxy utilized in conjunction with the present invention is a highly precise methodology with the ability to prepare epitaxial layers with atomic dimensional precision down to a few angstroms. Support for this statement is found in "Molecular Beam Technologyof III – V Compound Semiconductors of Optoelectric Applications," by K-Y Cheng http://ieeexplore.ieee.org/iel3/5/14175/00649646.pdf. Claim 13 has been amended to reflect this MBE derivation aspect. Rajavel utilizes a buffer layer (20) of a first Hg-based II-VI material, an overlayer (22) including detector (26) over the buffer layer formed of a second Hg-based II-VI material, a semiconductive substrate (14), and an initiation layer (18) between the buffer layer and the semiconductive support comprising a II-VI semiconductor material. In contrast, Claim 13 of the present invention recites, ***inter alia***, a multilayer structure, comprising a silicon based substrate; and an epitaxial $Cd_{1-z}Zn_zX_xX'_{1-x}$ film grown on the silicon based substrate, where X is a chalcogenide selected from the group consisting of S and Se; X′ is a higher atomic number chalcogenide relative to X and X′ is selected from the group consisting of S, Se and Te. Claim 13 further recites a $Hg_{1-y}Cd_yTe$ layer grown on the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film, and that the $Hg_{1-y}Cd_yTe$ layer is ***substantially lattice matched*** to the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film. Rajavel teaches away from this aspect inasmuch as Rajavel incorporates a "passivation" layer 16 that passivates the semiconductive substrate 14 and facilitates the epitaxial deposition of the initiation layer 18. Rajavel further teaches away from the present invention in that Rajavel employs multiple layers for matching compounds. Also, in Rajavel it is preferred that the buffer layer 20 and detector layer 26 contain no magnesium, sulphur and selenium.

Accordingly, one of ordinary skill in the art would not only ***not*** have a motivation to combine the references as indicated by the Examiner, but would be motivated ***not to combine*** the references as suggested by the Examiner.

***Han*** discloses a process for preparing quaternary nanocrystals comprising providing a reaction mixture containing the elements M1, M21, A and B each in a form suitable for generating nanocrystals and heating the reaction mixture for a sufficient period of time at a temperature suitable for forming said quaternary nanocrystals $M1_{1-x}M2_{x}A_{y}B_{1-y}$ and then allowing the mixture to cool. Han discloses a process for preparing quaternary nanocrystals by an entirely different process than the MBE process of the present invention.

***Mitra*** uses a method of annealing to produce interdiffused layers of Hg based alloys. Mitra solves the problem of mismatched lattice constants by interposing a buffer layer that has a lattice constant substantially similar to, for example, HgTe. See Col 3, lines 31-36:

> A buffer layer 22 is formed on the surface of the substrate 20 by epitaxial growth. The layer 22 comprises $Cd_{1-y}Zn_{y}Te$ which is grown in a conventional manner. The layer 22 has a thickness in the range of 2-10 microns and a Zn mole fraction of 0.056 to achieve a lattice constant substantially similar to HgTe.

As Applicant stresses in its Application, the novelty of the instant invention is to solve the lattice mismatch in long wavelength HgCdTe devices. See paragraph [0004] line1-3:

> However, to advance this technology to long wavelength (LWIR, 8-12 □m) HgCdTe devices, **lattice matching to HgCdTe** is needed in order to reduce the dislocation density within the material. **(emphasis added)**

As to Mitra, Mitra discloses a variable bandwidth absorbing material Hg1-xCdxTe that is manufactured using the MOCVD-IMP (Metalorganic Chemical Vapor Deposition-Interdifused Multilayer Process) process. In contrast, the present invention is directed to a Molecular Beam Epitaxy growth methodology used to provide an epitaxial $Cd_{1-z}Zn_{z}X_{x}X'_{1-x}$ film grown on the silicon based substrate.

The ***Chen, et al.*** (Chen) reference was authored by the inventors of the present invention. Chen does not disclose an epitaxial quaternary cadium chalcogenid film grown on the silicon based substrate. Chen also appears to suggest that improved results would be obtained under Zinc rich conditions (see page 273). In contrast, at paragraph 54 of the specification, it states:

> Figure 12 shows the dislocation density of CdZnSeTe/Si as a function of Zn and Se concentrations. As seen in the figure, a significant increase of the dislocation density occurs when Zn and/or Se concentration approaches 2 %. . . . Of special interest are CdZnSeTe/Si layers with low

Zn concentration and pure CdSeTe/Si layers which exhibits both excellent surface morphology and low dislocation density.

The Chen reference does not disclose or suggest the feature of ***low zinc concentration*** in an epitaxial ***quaternary*** cadium chalcogenid film grown on the silicon based substrate.

These features have been incorporated into the pending claims, as for example, claim 13 recites the ***quaternary*** cadium chalcogenid film of the formula $Cd_{1-z}Zn_zX_xX'_{1-x}$ where z is and z is a number greater than .005 and less than .015. It is noted that Chen does not disclose the enabling disclosure for the growth of $Cd_{1-z}Zn_zSe_xTe_{1-x}$ as provided in the specification at pages 10-12, wherein the growth of $Cd_{1-z}Zn_zSe_xTe_{1-x}$ is described, including the preparation of the substrate, including steps involving cleaning, heating and cooling.

As amended, claim 13 reflects the recognition that the growth of the $CdSe_{.04}Te_{.96}$ layer produces smooth surface because of the low Zn concentration (see paragraph 54 of the specification, and the $CdSe_{.04}Te_{.96}$ film is substantially lattice matched to the overlayer of $Hg_{.78}Cd_{.22}Te$. This concept is not recognized in the applied prior art. Likewise, claim 25 has been amended to recite the quaternary $Cd_{1-z}Zn_zSe_xTe_{1-x}$ film, which is not disclosed in Chen, and that z is greater than zero and less than or equal to .02, which correlates to two percent zinc concetration Independent claim 69 is also distinguishable over Chen in that, *inter alia*, the $Cd_{.97}Zn_{.03}Se_{.01}Te_{.99}$ film (also not disclosed in Chen) is three percent zinc.

As to the secondary references applied in conjunction with Chen as the base reference, Rajavel teaches away from the present invention for the reasons discussed above, including utilizing buffer layers. Han discloses a process for preparing quaternary nanocrystals by an entirely different process as discussed above.

A prior art reference must be considered in its entirety, i.e., as a <u>whole</u>, including portions that would lead away from the claimed invention. *W.L. Gore & Associates, Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303 (Fed. Cir. 1983), *cert. denied*, 469 U.S. 851 (1984). In *W.L. Gore*, claims were directed to a process of producing a porous article by expanding shaped, unsintered, highly crystalline poly(tetrafluoroethylene) (PTFE) by stretching said PTFE at a 10% per second rate to more than five times the original length. The prior art teachings with regard to unsintered PTFE indicated the material did not respond to conventional plastics processing, and suggested that the material should be stretched ***slowly***. The court held that a reference teaching rapid stretching of conventional plastic polypropylene with reduced crystallinity combined with a reference teaching stretching unsintered PTFE would not suggest ***rapid*** stretching of highly crystalline PTFE, in light of the disclosures in the art that teach away from the invention, i.e., that the conventional polypropylene should have reduced crystallinity before stretching, and that PTFE should be stretched slowly. In the present case, Molecular Beam Epitaxial (MBE) growth is used to produce an epitaxial $Cd_{1-z}Zn_zX_xX'_{1-x}$ film grown on the silicon based substrate and a radiation sensing $Hg_{1-y}Cd_yTe$ layer is grown on the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film such that the $Hg_{1-y}Cd_yTe$ is substantially lattice matched to

the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film. With the present invention, low zinc concentrations are used to achieve highly desired results. It is respectfully submitted that it would not be proper to combine the selected prior art references together without consideration of the specific conditions and concentrations necessary to obtain the desired results as detailed above.

In addition, in regard to the rejection on page 7 of the Office Action employing Chen in view of Rajavel and Han, there is no suggestion in the prior art that substituting the material(s) from Rajavel and Han would be beneficial. As discussed in the Examination Guidelines for Determining Obviousness Under 35 U.S.C. 103 in View of the Supreme Court Decision in *KSR International v. Telefex Inc.*, the Examiner has not shown (a) that there is some teaching, suggestion or motivation either in the Rajavel and Han references or in the knowledge generally available to one of ordinary skill in the art to modify the Chen disclosure, and (b) that there would be a reasonable expectation of success in so modifying the Chen device. Accordingly, it is respectfully requested that the rejection of the claims be withdrawn.

Moreover, regarding the specific indices, ranges of values and/or parameters specified in the claims, as discussed in the MPEP 2144.05, the Examiner has not shown that the prior art recognizes the results achieved by the claimed ranges and parameters using MBE technology. In contrast, it is believed that the inventors were the first to recognized the desirability of specific parameters, such as the low concentration of zinc, wherein the MBE growth of the $Cd_{1-z}Zn_zX_xX'_{1-x}$ film layer produces smooth surface because of the low Zn concentration (see paragraph 54 of the specification) and this film layer is substantially lattice matched to the overlayer in order to optimize the performance results. *In re Antonie*, 559 F.2d 618, 195 USPQ 6 (CCPA 1977) (The claimed wastewater treatment device had a tank volume to contractor area of 0.12 gal./sq. ft. The prior art did not recognize that treatment capacity is a function of the tank volume to contractor ratio, and therefore the parameter optimized was not recognized in the art to be a result-effective variable.). For example, claim 69 recites:

> A $Cd_{.97}Zn_{.03}Se_{.01}Te_{.99}$ film grown on a single crystal silicon (2 1 1) oriented based substrate having an overlayer of $Hg_{.78}Cd_{.22}Te$ thereon, wherein the growth of the $Cd_{.97}Zn_{.03}Se_{.01}Te_{.99}$ film is substantially lattice matched to the overlayer of $Hg_{.78}Cd_{.22}Te$.

Chen reference does not (a) disclose formulating the epitaxial $Cd_{.97}Zn_{.03}Se_{.01}Te_{.99}$ film layer and (b) appears to imply that improved results would be obtained under Zinc rich conditions (see page 273). The Chen reference does not teach the concept of producing a three percent level of Zinc as in claim 69; nor does it teach that a three percent level of zinc would have been optimal to a person of ordinary skill in the art. In contrast, at paragraph 54 of the specification, it states:

> Figure 12 shows the dislocation density of CdZnSeTe/Si as a function of Zn and Se concentrations. As seen in the figure, a significant increase of the dislocation density occurs when Zn and/or Se concentration approaches 2 %. . . . Of special interest are CdZnSeTe/Si layers with low

Zn concentration and pure CdSeTe/Si layers which exhibits both excellent surface morphology and low dislocation density.

Accordingly, it is respectfully submitted that the rejection of claim 69 be withdrawn in that the parameters recited in claim 69, as well as the other independent claims, are advantageous and the results realized by changing the parameters to those recited in the claims were not recognized by the prior art. See *In re Antonie*, 559 F.2d 618, 195 USPQ 6 (CCPA 1977).

Support for the recitation in claim 13 of a multilayer structure for use in a device for detection of microwave, millimeter, infrared (IR), ultraviolet, X-ray or gamma radiation is found at paragraphs 56 and 57. Support for the addition of the limitation in Claim 13 of by molecular beam epitaxy from multiple material sources where the flux of each of the multiple material sources is controlled under a given set of epitaxial growth conditions including temperature is found in paragraphs 29 and 30 of the specification. Support for the limitation in claim 13 of z is a number greater than or equal to .005 and less than .015 is found at paragraph 53. Support for the recitations in claim 13 of such that the effects of any mismatch are insignificant to device performance and such that the surface defect density is less than 500 per centimeter squared is found at paragraphs 58 and 28, respectively. These limitations, *inter alia*, further distinguish the present invention over Chen, alone, or in combination with Rajavel and Han.

Support for the recitations in Claim 14 of wherein the concentration of Zn and Se approaches two percent and z+x approaches .04 is found at paragraph 52 and support for the recitation of the epitaxial layer is grown by substrate rotation throughout the growth process to produce lateral surface uniformity and low film dislocation density is found at paragraphs 55 and 56 of the specification. These limitations, *inter alia*, further distinguish the present invention over Chen.

Support for the recitation in claim 26 of y varies within a range of approximately .2 for long wavelength IR (LWIR) to a value of .4 for short wavelength IR is found in U.S. Patent No. 5,432,374, which has been incorporated by reference. These limitations, *inter alia*, further distinguish the present invention over Chen, alone, or in combination with Rajavel and Han.

Support for the recitation in claim 70 of the $Cd_{.97}Zn_{.03}Se_{.01}Te_{.99}$ film grown on a single crystal silicon (2 1 1) oriented based substrate recited in claim 69, where the $Cd_{.97}Zn_{.03}Se_{.01}Te_{.99}$ film is grown on the single crystal silicon (2 1 1) oriented based substrate utilizing CdTe(211)B face is found at paragraph 33. This limitation, *inter alia*, further distinguishes the present invention over Chen, alone, or in combination with Rajavel and Han.

Applicant respectfully requests that a timely Notice of Allowance be issued in this case. The Director is hereby authorized to charge any additional fees or underpayments under 37 C.F.R. § 1.16 & 1.17; and credit any overpayments to Deposit Account No. **19-2201** held in the name of U.S. Army Materiel Command.

Respectfully submitted,

Intellectual Property Counsel

U.S. Army Research Laboratory

By _____

Lawrence E. Anderson
Reg. No. 29,503
Tel.: 301-394-0613
FAX: 301-394-3972
*e-mail*: larry.e.anderson@us.army.mil

ATTN: AMSRD-ARL-0-CC-IP
2800 Powder Mill Road
Adelphi, Maryland 20783-1197